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A Joint Sea Beam/SeaMARC II Survey of the East Pacific Rise and Its Flanks, 7°50'-10°30'N, to Establish a Geologic Acoustic Natural Laboratory

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A Joint Sea Beam/SeaMARC II Survey of the East Pacific Rise and Its Flanks, 7°50'-10°30'N, to Establish a Geologic Acoustic Natural Laboratory

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Long Range Scientific Objectives

Our goal is to understand the primary variables that control the shape of the deep ocean floor and to be able to predict the importance of terrain elements at various scales in areas which are not completely mapped at a fine scale.

Project Objectives

The primary project objective is to establish a long-term Geologic/Acoustic Natural Laboratory (GANL) near 8°-10°N on the East Pacific Rise. Our Nov-Dec 1990 cruise has established the GANL boundaries for a fast-spreading environment and provides total coverage at a large scale within the area using combined Sea Beam and SeaMARC II bathymetry and side scan sonar. Incorporating earlier SeaMARC II and Sea Beam surveys, the area of the GANL in which total coverage exists is approximately 140,000 km^2. The principal study area extends from 7°50'-10°30'N and 102°-106°W. Twenty km wide surveys extend coverage along the EPR to 4°50'N and along the Siqueiros fracture zone to 100°30'W.

Current Status and Progress

The completed GANL survey includes these key terrain elements:

(1) a remarkably uniform plate fabric of abyssal hills and normal faults striking ~359° (for areas of age 2-3 Ma) to 346° (the present);
(2) two major fracture zones (first-order discontinuities), one which is left-stepping (Siqueiros) and one which is right-stepping (Clipperton);
(3) numerous seamounts, seamount chains and one very prominent volcanic ridge near 8°20'N striking east-west;
(4) a rapidly evolving series of intra-transform spreading centers along the Siqueiros fracture zone for at least the last 4 Ma;
(5) several discordant zones associated with extinct overlapping spreading centers;
(6) all four orders of ridge axis discontinuities;
(7) a range of sediment cover including bare, highly reflective seafloor and sediment-inundated abyssal hills.

Preliminary observations show a continuous 6°-12° counter-clockwise change in the direction of spreading over the last 2-4 Ma. This change is evident in the magnetic lineations, the abyssal hill trends and fracture zone fault trends. The fracture zone changes azimuth from ~080° for recent times to ~087°-089° for the oldest extent of the survey. This has produced shortening across the Clipperton and the absence of intra-transform spreading, and opening across the Siqueiros with sustained intra-transform spreading. An excess in magma supply also feeds Siqueiros intra-transform spreading as well as a 1 km high, 200 km long east-west trending active volcanic ridge near 8°20'N on the west flank of the EPR.

Seamount chains are especially abundant on the west flanks of the rise, some paralleling the plate motion vector, others paralleling the relative plate motion direction. Numerous OSCs have appeared, migrated along axis, and disappeared on a time scale of 0.5-2.0 Ma.

Future work will focus on the significant task of combining this survey with three 1987 SeaMARC II surveys of the Clipperton transform, the 9°N OSC and the Siqueiros transform. Side-scan sonar mosaics and bathymetric surveys (Sea Beam and SeaMARC II) need to be shifted and spliced together digitally, including depth and gain adjustments. Error analysis of coincident SeaMARC II and Sea Beam, bathymetric data must be performed, as complicated but correctable errors in SeaMARC II bathymetric data have been found.

We will also merge gravity and magnetics data from the present cruise and many other cruises within the GANL boundaries to study the deep structure of the area. Three-dimensional inversions of the potential field data will be completed in FY91 and FY92.

The 1990 ONR-funded GANL cruise was successful beyond our expectations, but much work remains to be done in processing this enormous data set.

FY 90 Publications

Macdonald, K.C., 1989, Tectonic and magmatic processes on the East Pacific Rise, in Winterer, E.L., D.M. Hussong and R.W. Decker, eds., The Geology of North America: The Eastern Pacific Ocean and Hawaii, v. N, Geological Society of America, Boulder, 93-110.

Macdonald, K.C., 1989, Anatomy of the magma reservoir, Nature 339:178-179.

Macdonald, K.C. and P.J. Fox, 1990, The mid-ocean ridge, Scientific American 262:72-79.

Carbotte, S.M., and K.C. Macdonald, 1990, Causes of variation in fault facing direction on the ocean floor, Geology 18:749-752.

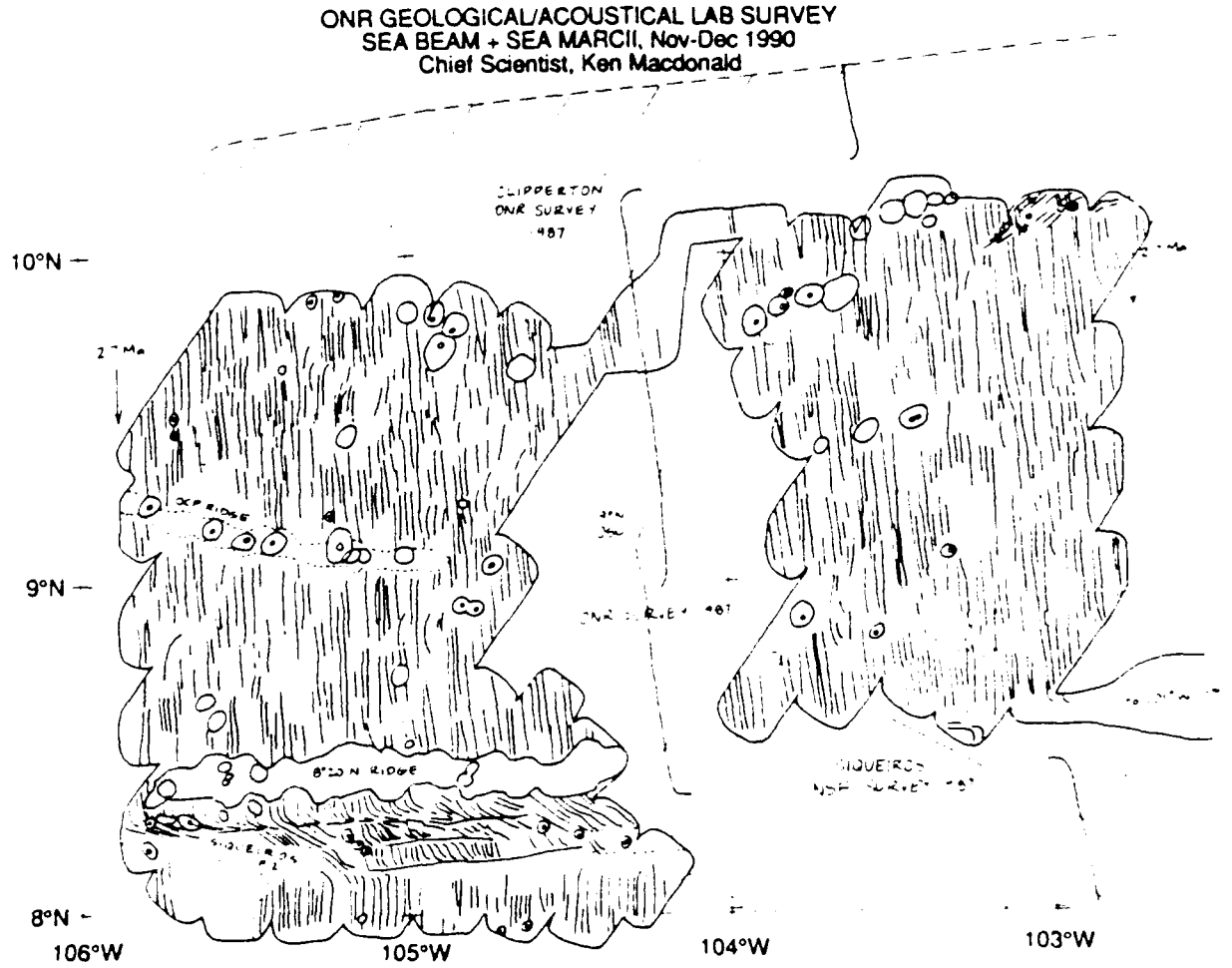
Perram, L.J. and K.C. Macdonald, 1990, Three dimensional magnetic modelling of an overlapping spreading center: 11°45'N on the East Pacific Rise, EOS Trans. AGU 70:1317.

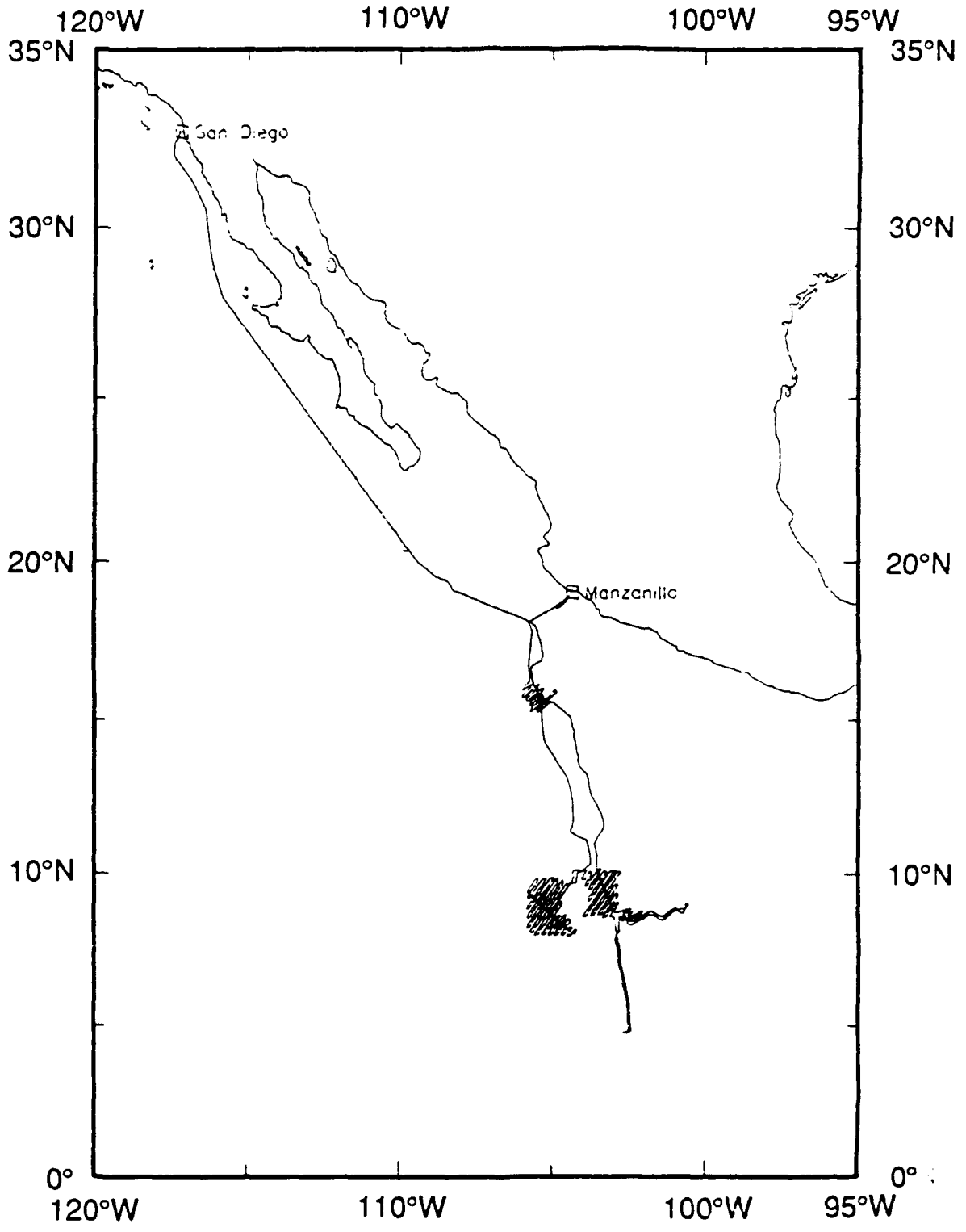
Macdonald, K.C., 1990, Endeavor Seamount, De Steiguer Ridge and Magic Mt.: Examples of migrating high inside corners caused by coupled uplift at the intersections of rifted spreading centers and ridge axis discontinuities, EOS Trans. AGU 70:1302.

Carbotte, S.M. and K.C. Macdonald, 1990, Why normal faults on mid-ocean ridges dip toward the spreading axis for slow spreading rates and both toward and away from the axis for fast spreading rates, EOS Trans. AGU 70:1302.

Macdonald, K.C. and D.S. Scheirer, 1990, Why long segments lengthen at the expense of short segments, EOS Trans. AGU 71:1629-1630.

Carbotte, S.M. and K.C. Macdonald, 1990, Evolution and history of the OSC at 9°03'N from three-dimensional analysis of magnetic data, EOS Trans. AGU 71:1629.





Rapa Leg 1 [RAPA01WT]
San Diego to Manzanillo
15 November – 15 December 1990